ECOLOGICAL STUDIES ON THE IMPROVEMENT OF NATURAL GRASSLAND I. THE VELOCITY AND THE TYPE OF PLANT COMMUNITY CHANGES DUE TO FERTILIZATION AND CUTTING, AND THE AMOUNT OF THE GRASS VARIES WITH THESE CHANGES

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ECOLOGICAL STUDIES ON THE IMPROVEMENT OF NATURAL GRASSLAND

I. THE VELOCITY AND THE TYPE OF PLANT COMMUNITY CHANGES DUE TO FERTILIZATION AND CUTTING, AND THE AMOUNT OF THE GRASS VARIES WITH THESE CHANGES

By

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Introduction

As the productivity of most natural grassland in Japan is low, many experiments have been undertaken to find methods for its improvement. The main reason for the low productivity seems to be due to the yearly use of the grassland without supplying plant nutrients which were lost through cutting or grazing. The short growth-period of the grass in the natural grassland also seems to lower the value of its utilization. From these facts we conclude that a sufficient supply of plant nutrients by fertilization is of first importance to increase the productivity of the grassland.

This investigation was made to ascertain the velocity and the type of plant community changes due to fertilization and cutting; and also to determine how the amount of the grass varies with these changes.

Methods

This four-year test was conducted on the experimental farm of the Agricultural Department of the Tohoku University. The farm is in the town of Narugo, Tamazukuri-gun, Miyagi Prefecture and is located at an altitude of about 500 meters above sea level.

The plain has a vegetation classified by Iizumi (1) as the *Miscanthus sinensis-Pteridium aquilinum-Potentilla Freyniana Type*, by Yoshida (2) as the *Miscanthus Stage* (or *M.-Pteridium Type*), and by Oseko (3) as the *Miscanthus Stage.* The chemical properties of the soil are shown in Table 1.

Table 1. Analytical table of experimental plot soils.

Layer	Depth	Soil texture	Soil color	C%	Humus	N%	C/N	Exchangeable CaO %	y_1	KCl pH
	cm				%					
I	0∼14	Loam	black	8.91	15.35	0.44	20.34	0.022	9.00	4.3
II	15∼24	Loam	dark black brown	8.01	13.80	0.39	20.81	0.016	8.30	4.4
III	25∼29	Loam	black	7.55	13.00	0.32	23.52	0.018	10.60	4.4
IV	30∼39	Clay loam	dark brown	4.44	7.65	0.26	17.14	0.022	3.80	4.5
V	40∼	Clay	brown	1.05	1.81	0.10	10.10	0.010	0.05	4.9

There were 16 kinds of experimental plots including the following general types: (a) NPK plot, (b) Nitrogen plot, (c) Phosphate plot, (d) Potassium and (e) Calcium plot. These plots were further classified according to the amount of each element added to each of the three groups: (1) the plots given 9 *kan* (1 kan = 3.75 kg) per *tan* (1 tan = 991.736 m^2) (2) the plots given 3 *kan* per *tan* and (3) those given 0.75 *kan* per *tan*. Besides these there was one plot to which no fertilizer was added (Table 2). The size of each experimental plot was 1/50 *tan* and four plots of the same kind were arranged by a randomized method. The period of fertilization was in the middle of May for four years, the fertilizer being spread on the surface of the ground. (During this period most grasses had not yet sprouted in these test plots).

Table 2. Experimental plot and degree of fertilizer. (kan/tan, 1kan = 3.75kg, 1tan = 991.736m^2)

	Ammonium sulphate-N	Superphosphate-P_2O_5	Potassium chloride-K_2O	Calcium carbonate-CaO
Cont.	0	0	0	0
NPK_1	9.00	9.00	9.00	
NPK_2	3.00	3.00	3.00	
NPK_3	0.75	0.75	0.75	
N_1	9.00			
N_2	3.00			
N_3	0.75			
P_1		9.00		
P_2		3.00		
P_3		0.75		
K_1			9.00	
K_2			3.00	
K_3			0.75	
Ca_1				9.00
Ca_2				3.00
Ca_3				0.75

The investigation was made in mid-August of each year (just before the *M. sinensis* came to head). The grasses taken from a optional 1 m^2 of the 1/50 *tan* were used to measure the degree of cover, the number of stems and the green weight. Often after the investigation, the grasses of the experimental plots were cut at about 10 cm from the ground.

The change of the plant community was studied by measuring the degree of cover (100), the green weight (100) and number of stems (100) of the plants composing the plant community and by calculating the dominance (300/3) from them.

The total weight and palatable plants were shown by converting the weight of 1 m^2 into that of *tan.*

Results

I. Change of Plant Community (Fig. 1)

(1) The non-fertilization plot

In this grassland, *M. sinensis* was predominant, and *P. aquilinum* was abundant; *Arundinella anomala* and *Spodiopogon sibiricus* were mixed in it. Many *P. Freyniana, Hydrocotyle ramiflora, Halorrhagis micrantha, Carex nervata* and *Carex Lanceolata* as "short grass" were also found.

According to the continuation of the cutting each year, *P. aquilinum, Zoysia japonica* and *H. ramiflora* increased remarkably, while at the same time *M. sinensis, A. anomala* and *S. sibiricus* decreased in dominance.

This shows that there is a tendency of *P. aquilinum-Z. japonica-P. Freyniana Type* to follow immediately the *M. sinensis-P. aquilinum-P. Freyniana Type* by annual cutting (in mid-August) after 4 successive years of experimenting.

(2) NPK_1 The dominance of *M. sinensis* was markedly high until '54. *P. aquilinum* became the dominant species and *Polygonum Reynoutria, Calamagrostis hakonensis, Iris Kaempferi* and *Artemisia vulgaris* increased from '53, having no short grass. The plant community resembled the "*Hochstauden flur*".

(3) NPK_2 In '52 each species grew well; in '53 the amount of *P. aquilinum* decreased, but that of *M. sinensis* increased. *A. anomala, S. sibiricus* and *Lespedeza bicolor* flourished. In '54, the dominance of *M. sinensis* increased markedly and in '55, that of *P. aquilinum* became higher. Short grass disappeared. *P. Reynoutria,* and *Calamagrostis hakonensis* increased and showed aspects similar to NPK_1.

(4) NPK_3 In '52, the dominance of *M. sinensis* was only medium, but that of *P. aquilinum, A. Ansmela, S. sibiricus* and *Z. japonica* was high. In '54, *M. sinensis, A. anomala* and *S. sibiricus* decreased, and *L. bicolor, P. aquilinum, H. ramiflora* and *Z. japonica* increased.

In '55, *P. aquilinum* dominated and *M. sinensis, A. anomala* and *S. sibiricus* decreased. There was little change in *P. Freyniana* during the experimental period.

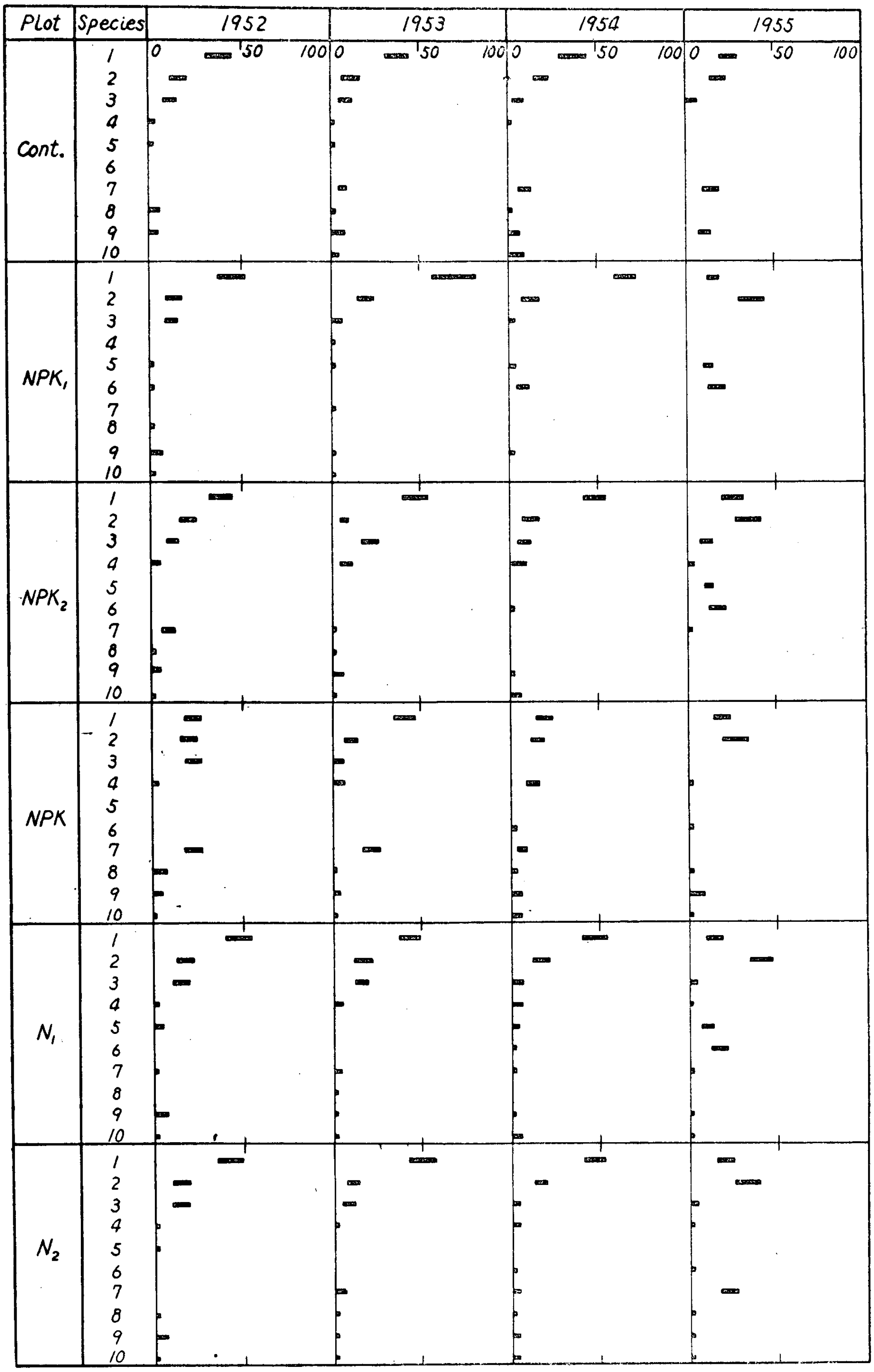

Fig. 1–1. Change of dominance.

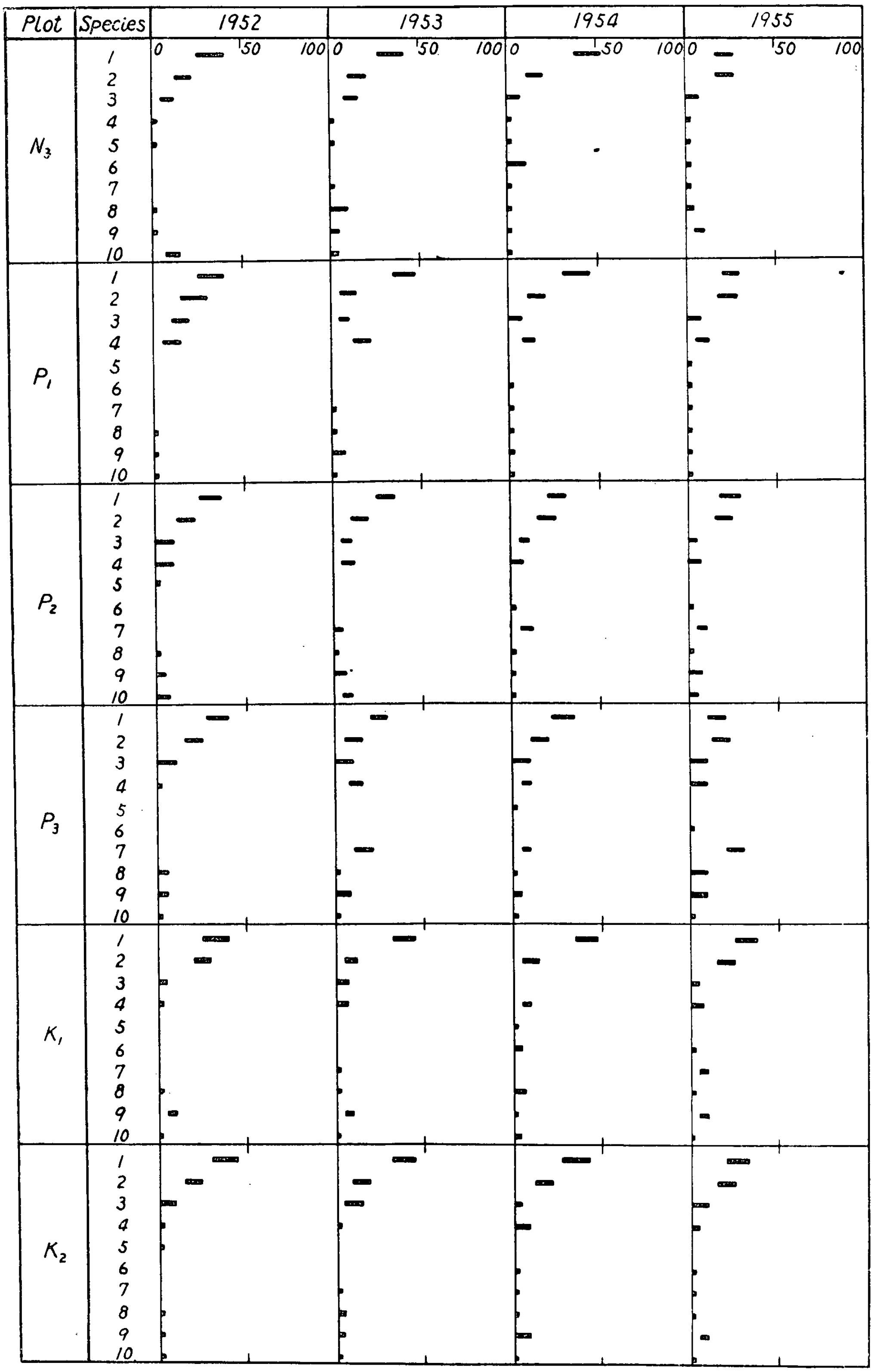

Fig. 1-2. Change of dominance.

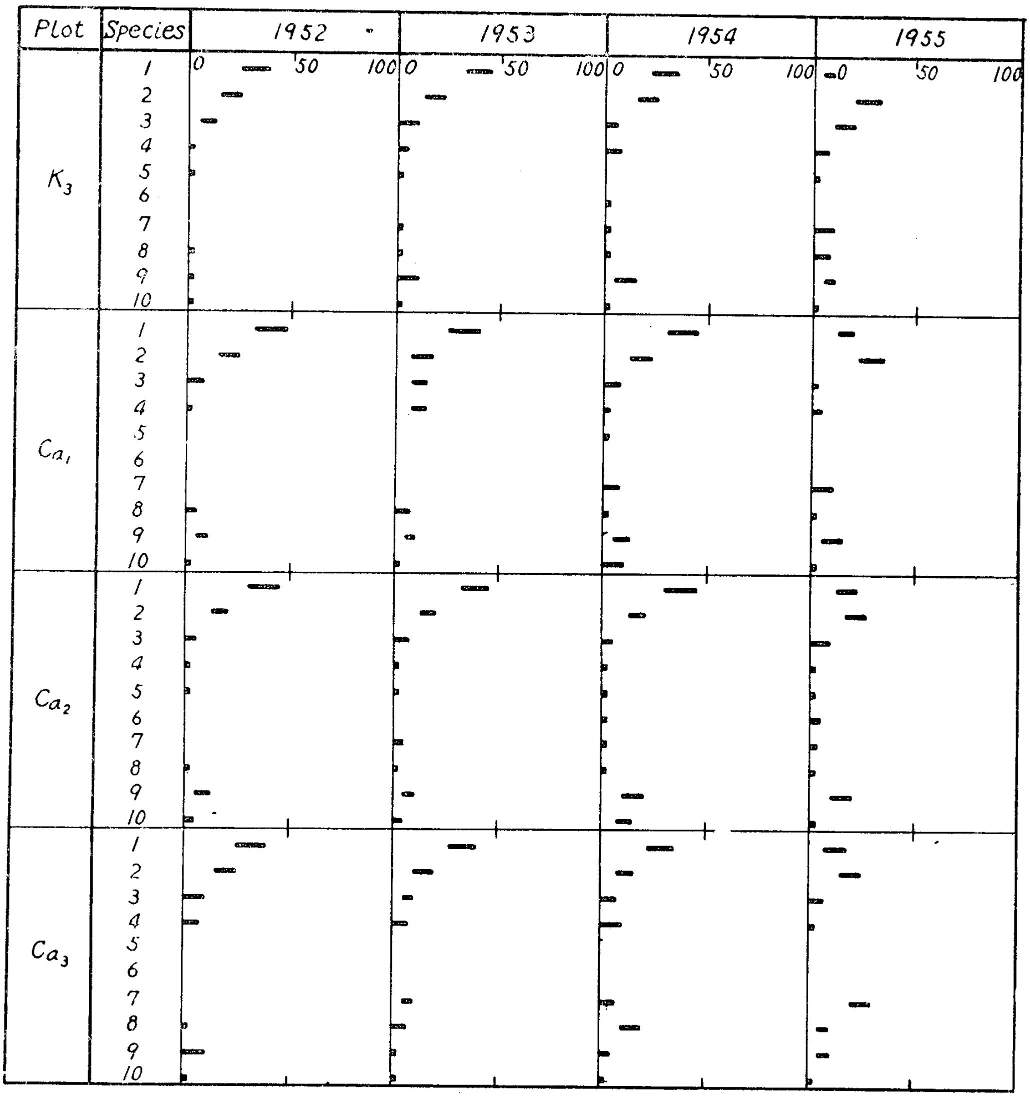

Fig. 1-3. Change of dominance.
(shown by confidence range in 95% reliability.)

Note. Species of plant : 1. M. sinensis, 2. P. aquilinum, 3. A. anomala, 4. L. bicolor, 5. P. Reynoutria, 6. C. hakonensis, 7. Z. japonica, 8. H. micrantha. 9. P. Freyniana, 10. H. ramiflora.

(5) N_1 In '52, no change was seen in *P. aquilinum*, but the dominance of *M. sinensis* became high and *P. Reynoutria* increased also. In '53 and '54, there was no great difference from that in '52; but, during this period the growth of *A. anomala*, *S. sibiricus* and *L. bicolor* increased and then decreased. In '55, the dominance of *M. sinensis* decreased and that of *P. aquilinum* and *P. Reynoutria* increased remarkably; the short grass decreased extremely and showed almost the same kind of plant community as NPK_1.

(6) N_2 In '52, '53 and '54, *M. sinensis* dominated highly, but in '55, the dominance suddenly decreased, contrary to *P. aquilinum* which increased in '55. The dominance of *A. anomala* and *S. sibiricus* became lower year after year, but that of *Z. japonica*, higher. *H. ramiflora* was strong in '54. This indicates the succession from the *M. sinensis-P. aquilinum-P. Freyniana Type* to the *P. aquilinum-Z. japonica-P. Freyniana Type.*

(7) N_3 In '52, *M. sinensis* had high dominance and *P. aquilinum, A. anomala* and *S. sibiricus* were next in order. In '53 and '54 they were almost the same as that of previous year. In '55 the dominance of *M. sinensis* decreased and was as low as that of *P. aquilinum.*

(8) P_1 In '52, the plant community was similar to that of the non-fertilized plot. The dominance of *L. bicolor* increased remarkably, but it decreased gradually after attaining its maximum in '53. The dominance of *M. sinensis* was high in '53 and '54, but it was almost the same as that of *P. aquilinum* in '55.

(9) P_2 The dominance of *A. anomala* and *S. sibiricus* was low in '52, but that of *L. bicolor* was high like that of P_1. The dominance of *L. bicolor* reached its maximum in '53 and then decreased gradually. *P. Freyniana* decreased also, while *Z. japonica* and *H. ramiflora* increased remarkably each year.

(10) P_3 The plant community in '52 showed no difference from that of the non-fertilized plot, but *Z. japonica* increased and became the dominant species in '55. Though *L. bicolor* increased in '53 and '54, it decreased in '55. *M. sinensis* was highly dominant till '54, but in '55 it was equal to *P. equilinum.* This indicates the succession from the *M. sinensis-P. aquilinum-P. Freyniana Type* to the *Z. japonica-P. aquilinum-H. ramiflora Type* through the *P. aquilinum-Z. japonica-P. Freyniana Type.*

(11) K_1 The dominance of *M. sinensis* was remarkable till '55; there was no marked change in the dominance of *P. aquilinum*, it had a tendency to increase gradually. The dominance of *L. bicolor* increased from '53, but decreased in '55. *Z. japonica* increased in '55; no change was found in *P. Freyniana* during the experimental period. The data presented here shows there was the tendency of succession from the *M. sinensis-P. aquilinum-P. Freyniana Type* to the *M. sinensis-P. aquilinum-L. bicolor Type*, and then to the former type and still further to another type.

(12) K_2 Though the plant community of K_2 was almost the same as that of K_1, the dominance of *P. aquilinum* increased much more than that of K_1, and *M. sinensis* decreased.

(13) K_3 In '52, '53 and '54, the dominance of *M. sinensis* was highest, and *P. aquilinum, A. anomala* and *S. sibiricus* were next in order. In '53, *L. bicolor* increased, and in '55, the dominance of *P. aquilinum* increased exceedingly. *Z. japonica* increased also in '55. This shows the succession from the *M. sinensis-*

P. aquilinum-P. Freyniana Type to the *P. aquilinum-Z. japonica-P. Freyniana Type.*

(14) Ca_1 In '52, '53 and '54 the dominance of *M. sinensis* was high, and that of *P. aquilinum* was highest in '55. *A. anomala* and *S. sibiricus* decreased very much from '54. *Z. japonica* increased from '54 and *P. Freyniana* each year. *L. bicolor* was abundant in '52 and '53, but decreased from '54.

(15) Ca_2 The plant community was almost the same as that of Ca_1, but *L. bicolor* and *Z. japonica* were less than those of Ca_1. *P. Freyniana* and *H. ramiflora* increased each year.

(16) Ca_3 In '52, '53 and '54 the dominance of *M. sinensis* was highest but in '55 it came next to *Z. japonica* and *P. aquilinum*. *L. bicolor* was remarkable till '54, but decreased in '55. *H. micrantha* and *P. Freyniana* increased year by year.

II. Changes in Number of Species (Table 3)

Comparing with the number of species of the non-fertilized plot in 1952, those of NPK_1 and N_1 were reduced, and NPK_2 also, becoming fewer in the second and the fourth years, showed a tendency to decrease. N_2 had a tendency to decrease. The number of species in P_1 decreased in the first year, but thereafter remained uniform.

No species increased in their number in the experimental plots.

The plots in which the number of species decreased were those which showed a succession from the *M. sinensis-P. aquilinum-P. Freyniana Type* to

Table 3. Changes in number of species. (1 m²)

Plot \ Year	1952	1953	1954	1955
Cont.	23.0±1.4	24.2±1.2	20.7±1.5	24.2±0.5
NPK_1	※18.5±1.8	※11.5±2.3	※10.2±1.1	※ 6.2±1.7
NPK_2	21.0±1.2	※18.5±1.1	21.0±1.4	※16.5±2.1
NPK_3	20.7±1.6	20.0±1.4	21.7±1.6	21.7±2.4
N_1	※18.5±1.1	※16.0±1.2	※16.2±2.2	※12.2±2.5
N_2	※18.2±0.2	19.7±3.0	19.7±2.4	※18.5±2.3
N_3	20.2±1.7	21.2±2.7	23.2±1.3	20.0±1.2
P_1	※17.2±2.9	21.0±1.9	21.5±1.5	23.5±1.7
P_2	※19.7±1.5	22.0±2.5	22.2±0.7	22.7±1.7
P_3	21.0±1.5	23.0±2.4	25.2±1.9	24.2±0.8
K_1	21.2±1.9	20.2±0.9	20.5±2.7	24.5±1.4
K_2	21.2±1.2	21.7±1.6	23.2±1.6	23.5±2.1
K_3	20.5±1.1	24.7±1.3	23.5±0.9	25.0±2.6
Ca_1	20.7±1.8	24.0±1.8	25.7±1.3	25.7±1.4
Ca_2	21.2±1.5	25.0±1.8	24.5±0.2	24.5±1.3
Ca_3	20.2±2.2	23.0±2.2	24.0±1.4	24.2±2.4

※ … Significant at 5% level.

the type presenting aspects of the "Hochstauden flur". In the other plots there was neither an increase nor a decrease.

The main species which diminished were *Z. japonica*, *C. nervata*, *C. lanceolata*, *H. ramiflora*, *H. micrantha*, *Disporum smilacinum* and *A. japonica*.

III. Total Green Weight of Grasses (Table 4)

Comparing with the non-fertilized plot, the following five plots, NPK_1, NPK_2, N_1, N_2 and P_1 showed a remarkable increase in green weight of the grasses in the first year, and in the second year two more plots, NPK_3 and N_3, were added. In the third year, however, only the three plots, NPK_1, NPK_2 and N_2 showed an increase, while in the fourth year, the three plots, NPK_1, NPK_2 and N_3 were added.

Table 4. Total green weight of grasses (kg/tan 1tan = 991.736 m²)

Plot \ Year	1952	1953	1954	1955
Cont.	820±101	1220± 60	745± 34	640± 77
NPK_1	※4287±717	※4367±723	※3830±381	※2237±265
NPK_2	※1837±222	※2772±513	※2037±259	※1425±341
NPK_3	1107±111	※1947±524	1175± 65	1030± 43
N_1	※1985±218	※1915±243	975±143	770± 80
N_2	※1977±300	※1942±169	※1667±240	775±126
N_3	1220±120	※1632± 62	1132±190	※1042±169
P_1	※1267±139	※1645±143	685± 52	822±168
P_2	890± 60	1417±118	975±126	802±103
P_3	1185±153	1370±183	1007±136	777± 99
K_1	860±100	1557±261	732± 81	870±159
K_2	1107±159	1130±218	1067± 26	860± 77
K_3	952± 74	1605±363	805±131	592±103
Ca_1	1047±122	1445±165	1200±140	912± 40
Ca_2	987± 73	1557±245	1007± 52	842± 36
Ca_3	947±159	1172± 67	805± 92	762± 74

※ … Significant at 5% level.

From the first year through the fourth years, the two plots, NPK_3 and K_2 showed but little difference each year, while most of the other plots decreased markedly in the weight as compared with the second year.

There were five plots which showed a decrease compared with the first year: NPK_1, NPK_2, N_1, N_2 and P_2.

IV. Green Weight of Palatable Plants (Table 5)

Comparing with the non-fertilized plot, those which showed a remarkable increase in weight of palatable plants were NPK_1, NPK_2, N_1 and N_2 in the first year, NPK_1, NPK_2, NPK_3, N_2 and N_1 in the second year and NPK_1, NPK_2, and N_2 in the third year; in the fourth year no plot showed an increase. No plot palatable plants became less than in the non-fertilized plot.

Table 5. Green weight of palatable plants (kg/tan, 1tan = 991.736 m²)

Plot \ Year	1952	1953	1954	1955
Cont.	602±130	1027± 43	557± 62	420± 96
NPK_1	※3350±710	※3490±727	※2942±463	735±195
NPK_2	※1252±214	※2385±466	※1502±190	772±201
NPK_3	695± 71	※1580±491	765±107	650±150
N_1	※1470±200	※1497±309	660±176	327± 70
N_2	※1400±281	※1620±198	※1295±270	392±130
N_3	805± 60	1230±127	757±275	582±167
P_1	887±145	1300±227	505± 67	575±198
P_2	577± 62	1097±132	680± 95	487± 58
P_3	782±149	1040±164	695±163	500±134
K_1	515± 44	1035±231	652± 87	625±158
K_2	682±105	1082±183	690± 69	615±195
K_3	645± 90	1247±305	540± 96	345±106
Ca_1	727±168	1092±221	812±124	492± 87
Ca_2	680± 83	1160±343	665±114	447± 78
Ca_3	655±193	932± 93	655± 65	410± 17

※ ··· Significant at 5% level.

During the experimental period K_1 and K_2 showed no evident change; the other plots decreased in the green weight of the palatable plants markedly comparing with the second year.

The four plots, NPK_1, NPK_2, N_1 and N_2 showed a decrease more marked in the fourth year than in the first year.

Discussion

I. Change of Plant Community

Oseko, Yoshida and Iizumi have reported on the classification of the grassland types of natural grassland and its succession. Among these reports experiments on the velocity of succession was made only by Oseko who presumed the period of plant succession. Hitherto studies in this field have been directed to the classification of grassland types, therefore there has been no progress with regard to the velocity of sucession. Needless to say profitable usage of grassland is to ascertain the velocity of plant succession of a natural grassland. In this investigation we concentrated on the influence of fertilization and cutting upon the velocity of succession.

Oseko discussed the succession classifying the grassland types into ten stages; Yoshida, classified them into four stages and fifteen types and Iizumi, classified them into thirteen types. In this investigation the velocity of succession will be described according to Iizumi's classification, for the reason that he has dealt with the succession of each type in detail.

The changes of the plant community in the experimental plots are shown collectively in Fig. 2.

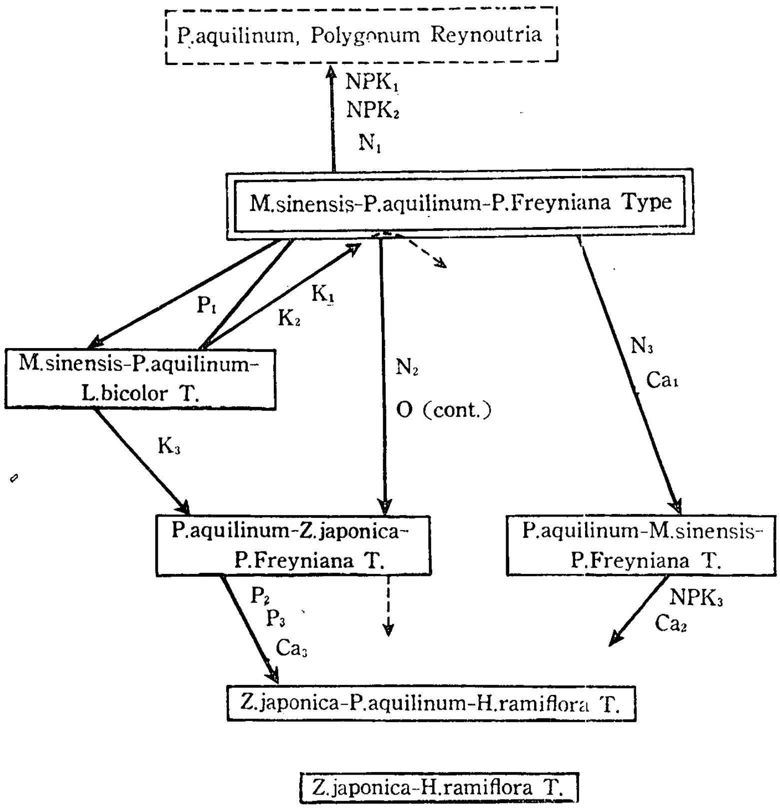

Fig. 2. Change of the Plant Community.

The main grassland types of Iizumi were found except for the *Z. japonica-H. ramiflora Type.* Having *M. sinensis - P. aquilinum - P. Freyniana Type* as its center, *P. Reynoutria* and *P. aquilinum* predominated in the NPK_1, NPK_2 and N_1 plots. The plots were succeeded by the type having the aspects like the "Hochstauden flur". This succession began to appear remarkably in each plot above mentioned in the third year. From the Fig. 2. it can be understood that this is due to nitrogen contents; further, a large amount of nitrogen contents results in the "Hochstauden flur" to grow rapidly.

The non-fertilized plot and the N_2 plot directly and the P_2 and the K_3 plots through the *M. sinensis - P. aquilinum - L. bicolor Type,* succeeded to the *P. aquilinum - Z. japonica - P. Freyniana Type*; the P_3 and the Ca_3 plots reached the *Z. japonica - P. aquilinum - H. ramiflora Type.* The P_2, non-fertilized and the N_2

plots showed a tendency to be succeeded by the *Z. japonica - P. aquilinum - H. ramiflora Type.* The K_1, K_2 and the P_1 plots showed a tendency of succession to the *M. sinensis - P. aquilinum - L. bicolor Type* in the second or third year, and the former to the *M. sinensis - P. aquilinum - Freyniana Type,* and further to the *P. aquilinum - M. sinensis - P. Freyniana Type* in the fourth year.

The NPK_3, N_3, Ca_1 and Ca_2 plots developed into the *P. aquilinum - M. sinensis - P. Freyniana Type.*

The Ca_2 and the NPK_3 plots further showed a tendency of succession to the *Z. japonica - P. aquilinum - H. ramiflora Type.* After the fouryear cutting the plots failed to develop into Iizumi's *Z.-japonica - H. ramiflora Type,* but there was found a tendency towards doing so. It is considered a fact that the plant community traced conversely the sere of plant community maintained by Iizumi proves the Iizumi's sere of plant community to be right. Oseko presumed that the succession from the *Miscanthus* Stage to the *Zoysia* Stage requires 10–30 years.

We and others, proved that when the grassland was used as a common natural meadow, many *Z. japonica* dominated there in the third year and in the fourth year the *Zoysia* Stage of Yoshida and Oseko appeared. These findings were recognized also in the changes of the height of the grasses.

When the grassland was used as a grazing land, the *Zoysia* Stage seems to succeed more quickly than in the case when it is used as a natural meadow; that is, the Japanese native black cattle grazed (about 50–70 cattle on 200 chobu (1 chobu = 1 ha.) on the grassland of *M. sinensis - P. aquilinum - P. Freyniana Type* for 150 days) and in the early stage the *P. aquilinum - Z. japonica Type* was developed in the same year and a rather extensive area (5–6 chobu) became this type. Comparing with cutting, grazing injures *M. sinensis* many times, and so it is presumed that the succession to the *Zoysia Type* occurs more quickly by grazing than by cutting.

Naturally, it is thought that the different speeds of the succession from the *Miscanthus* Stage to the *Zoysia* Stage may be due to the amount of disturbances caused by grazing and cutting or to the location and to the fertility of the meadow grassland.

It was proved that the extremely rapid succession of grassland type appeared by such common use as grazing or cutting. However, it is thought that if this grassland is not disturbed, such a change will not occur.

Every group belonging to the P and K plots showed the succession to another type through the *M. sinensis - P. aquilinum - L. bicolor Type.* This indicated that in the succession to the *M. sinensis - P. aquilinum - L. bicolor Type* from other type phosphate and potassium contents are necessary. The group of Ca plot had many *L. bicolor,* which shows that there is some relation between them. *L. bicolor* was found to be too weak for the cuttings and the *M. sinensis-*

P. aquilinum - L. bicolor Type appeared only in a small part of the grassland which was used for cutting.

The group of Ca plot passed through the *P. aquilinum - M. sinensis - P. Freyniana Type*. *P. Freyniana* was especially productive in the experimental plots of the Ca group. These facts are considered to indicate a close relation between calcium and *P. Freyniana*. Other plots which passed through this type were the NPK_3 and the N_3 plots. It is thus considered reasonable as reported by Yamane (4) that *M. sinensis* accumlates calcium near the soil surface. The fact that plots of high contents of potassium remained in the *M. sinensis - P. aquilinum - P. Freyniana Type* is considered to show that *M. sinensis* requires much potassium and the plots, if supplied with additional potassium, remain in this type longer than others after cuttings. The lack of potassium may be considered one of the causes for a rapid succession.

As in these experimental plots *Sasa* were not found, we could not seen the stages and types with *Sasa*. But we could make quickly experimentally each types of Iizumi and most stages and types of Yoshida.

II. Number of Species, Total Weight of Palatable Plants

We have already mentioned that the decrease in the number of species was found on the plots where the "Hochstauden flur" grassland type succeeded the *M. sinensis - P. aquilinum - P. Freyniana Type*. This type of plot is considered to be the result of applying much nitrogen. For that reason, until about the second year the total weight consisted mainly of palatable plants belonging to grass, but in the third year palatable plants or plants comparatively unparatable such as *P. aquilinum*, *Polygonum Reynoutria* and *Iris Kaempferi* increased. Consequently, herbage on natural grassland cannot be maintained by the same methods of fertilization as that of NPK_1, NPK_2 and N_1 plots.

The other plots showed a retrogressive succession, some plots having retrogressed from the *M. sinensis - P. aquilinum - P. Freyniana Type* to the *Z. japonica - P. aquilinum - H. ramiflora Type*, and the others, to the midway stage of the type. No change in the number of species was found in the plots.

On mountain grassland there is a great difference in dominance between grassland types, but there may be no remarkable difference in the number of species. In this study, the fact the number of species did not decrease may be due to the short time which had elapsed since the succession; that is, if the plant community remained for long comparatively in such a low stratum vegetation as the *Zoysia Type*, it may be considered that the number of species will decrease.

In any case the decrease in total green weight and in palatable species was found to be parallel with such a succession as this.

The palatable species in K_1 and K_2 plots did not change much and ran parallel with the change of vegetation. This indicates that the other plots locked potassium in the growth of *M. sinensis*, and that the supply of potassium would promote the growth comparatively, and therefore the maintenance of the palatable species would be possible.

However, the tendency of succession and retrogression was remarkable in each plot, and so the maintenance of vegetation by the present method of fertilization and cutting is considered very difficult.

In this investigation it was not classified whether the results were caused by the low resistibility of native grasses to cutting or grazing, or to an insufficient supply of plant nutrients, or to some other unrecognized factors.

Summary

This study has been made to ascertain the influence of fertilization and cutting upon the succession of a plant community and the velocity of its succession. In addition to this the total green weight of the grasses of each grassland type and also the changes in the weight of palatable species have been investigated.

1) By the fertilization and cutting most of the main grassland types investigated by Iizumi and Yoshida were produced.

2) Though up to now no report on the velocity of succession has been made, the writers have ascertained it to be very rapid.

3) It is difficult to maintain the plant growth of the natural meadow by the present methods of fertilization and cutting.

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